Research reports of the Finnish Transport Agency
50eng/2016

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Nordic field test; test signs 1996 →

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Finnish Transport Agency
Helsinki 2016

Cover photo: Test signs in Vantaa v.2002; Timo Unhola

Verkkojulkaisu pdf (www.liikennevirasto.fi)
ISSN-L 1798-6656
ISSN 1798-6664
ISBN 978-952-317-333-0

Liikennevirasto
PL 33
00521 HELSINKI
Puhelin 0295 34 3000

Timo Unhola: Durability of retro-reflecting materials for road signs – Nordic field test; test signs 1996->. Finnish Transport Agency, Technology and Environment. Helsinki 2016. Research reports of the Finnish Transport Agency 50eng/2016. 27 pages and 3 appendices. ISSN-L 1798-6656, ISSN 1798-6664, ISBN 978-952-317-333-0.

Keywords: traffic signs, durability, road trial

Summary

The purpose of the durability test of the retro-reflecting materials used on traffic signs was to examine their performance in real-world conditions along the road, at least for a period of 10 years.

Four test material signs were erected in Vantaa by the side of the road #4 and four similar signs by the road #79 just north of Rovaniemi. In addition, a reference test sign was erected close to each of them at the yard of the depot. Each of the test signs had the same 86 different kinds of retro-reflective material test slabs. In all the Nordic countries similar test signs were erected at 2 sites in each country, one in Iceland.

The performance of the materials was examined at the beginning of the experiment by measurements on an annual basis. For the first few years only the retro-reflectivity was measured, since 2001 also color coordinates. The total duration of the test in Finland was 19 years, much longer than in any of the other countries.

Based on the results it can be concluded that the test materials remained functional capacity well. Nearly two-thirds of all test materials conformed to the requirement of a new reflective material even after 19 years of aging. Aging in this experiment includes exposure to traffic, maintenance and weather impacts. Most of the materials which no longer met the requirements had lost their outer film or it was faded to a degree that the color coordinates had moved outside the requirement area.

There were smaller differences in performance with respect to the direction or the geographical site of the test signs than expected.

A problem arises during this kind of long lasting natural aging test: the product development is continuous and only a few of the materials tested are no longer for sale after 20 years.

Foreword

The reflective materials used in traffic signs developed rapidly in the 1990's. Especially new microprismatic reflective films became available from many manufacturers. The requirements of the different types of materials and their classes had to be revised.

Therefore, it was decided by the Nordic countries led by NMF (Nordisk MörkertrafikForskning, later Nordiskt Möte för Förbättrad vägutrustning), to arrange a common field trial, including similar trial signs along the roads in each country. As agreed in 1996, the experiment was started in the summer of 1997. The signs were measured at the beginning every year in different countries, and less frequently after that. In most countries, the test was stopped after ten years. In Finland, however, the signs were kept, and they were measured up to the last measurement of this year, meaning an aging of 19 years.

The Finnish Transport Agency (formerly Finnish Road Administration, Traffic Services) arranged the measurements by inspectors Kullervo Havu (-> 2004) and Per-Olof Linsén. They also authored an interim report covering the first years of the trial in Finland in 2000.

Timo Unhola (Research Scientist, VTT Technical Research Centre of Finland, Roadlux Ltd, retired) has done most of the measurements and has authored this report, which contains a summary of all the measurements.

For further information, contact Jukka Hopeavuori, Finnish Transport Agency.

Helsinki, November 2016

Finnish Transport Agency
Technology and Environment, Road Technology

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1 Introduction

Traffic sign surfaces are light-reflecting films having retro-reflective capability that must meet the minimum requirements under the different categories (color, class). Retro-reflectivity describes the night visibility of road signs under lighting of vehicle headlights. In addition, different colors have their own day visibility and color requirements, which are expressed as luminance factor and chromaticity coordinates. The requirements and definitions are presented in the standard SFS-EN 12899-1.

Nordic field trial of retro-reflective sign materials (1997-2016), its test method, measuring methods and equipment, as well as the results of the first measurements made in Finland have previously been presented in an interim report in 2000 [Pohjoismainen liikennemerkkikalvojen paluuheijastavuustutkimus; Väliraportti I (1997–1999) Suomi].

The entire trial, including test methods and results after 19 years, are summarized in this final report.

2 The purpose

The purpose of the experiment was to determine the durability i.e. the permanence of the day and night visibility of the different retro-reflective materials for traffic signs in real-world conditions along the road, at least for a period of 10 years

The location of the test signs aimed at achieving the broadest possible representativeness in the entire Finnish road network.

Since the trial was a joint Nordic study and measurements were taken at the same time and with similar equipment, reference data for comparison was obtained from other countries.

3 Implementation

According to agreement the trial was implemented in the same way in all the Nordic countries: Denmark, Finland, Iceland, Norway and Sweden, starting in 1997.

3.1 Trial sign location

Two trial sites were chosen in each country in accordance to the following table (1), except in Iceland, where there was only one place.

Table 1: Locations of the trial sites in the Nordic countries

Country	Location	Trial signs	Road address
Denmark	Frederiksborg	4+reference	Frederikssundsvej, 5 km south of Frederikssund
	Ribe	4	Ribe-Esbjerg, 15 km north of Ribe
Finland	Vantaa	4+reference	Vantaa, Hakkila, Road #4, 1,5 km north of Ring III
	Rovaniemi	4+reference	Nivankylä, Road #79, 10 km north of Rovaniemi,
Iceland	Reykjavik	2	east of Reykjavik
Norway	Arendal	4+reference	Arendal-Kristianssand, 9 km south of Arendal
	Røros	4+reference	Røros-Trondheim, 13 km north of Røros
Sweden	Linköping	4+reference	At Sjögestad, 15 km north of Linköping*)
	Gamleby	4	3 km south of Gamleby
*) moved to this location from a location near Linköping after a graffiti attack in 1998			

The trial sites in Finland were chosen deliberately on very different locations (see Figure 3). In the south the test signs (Figure 1), along the road #4 in Vantaa, were exposed to the stress caused by a traffic volume more than 50 000 vehicles daily (year 2010) along with spray from salt, mud and bitumen, the washing of signs, the cast material from plowing and temperature variations below and above zero degrees in winter.

In contrast, the site in the north, along a much smaller road #79 (ADT 3000, year 2010) was an almost unsalted road section in much cleaner environment, where in addition to plowing the traffic signs were tended to be cleaned from the snow with hot water.

Figure 1. *The south: Trial signs along road #4 in Hakkila (picture January 2004, Timo Unhola)*

Figure 2. *The north: Trial signs along road #79 in Nivankylä (picture April 2003, Timo Unhola)*

Figure 3. The location of Finnish trial sites (base map Finnish Transport Agency)

3.2 Trial site arrangement

Trial signs were placed and erected like regular traffic signs along the road at each location in the same way (Figures 4, 5, and cover photo): in the direction to the north two signs in a row, the first upright and the other inverted (upside down), in 25 m intervals. Similarly, the two signs were placed on the other side of the road. The arrangement intended to equal stress of all materials.

In addition, nearby was erected a reference trial sign, which was affected by weather only, none by traffic.

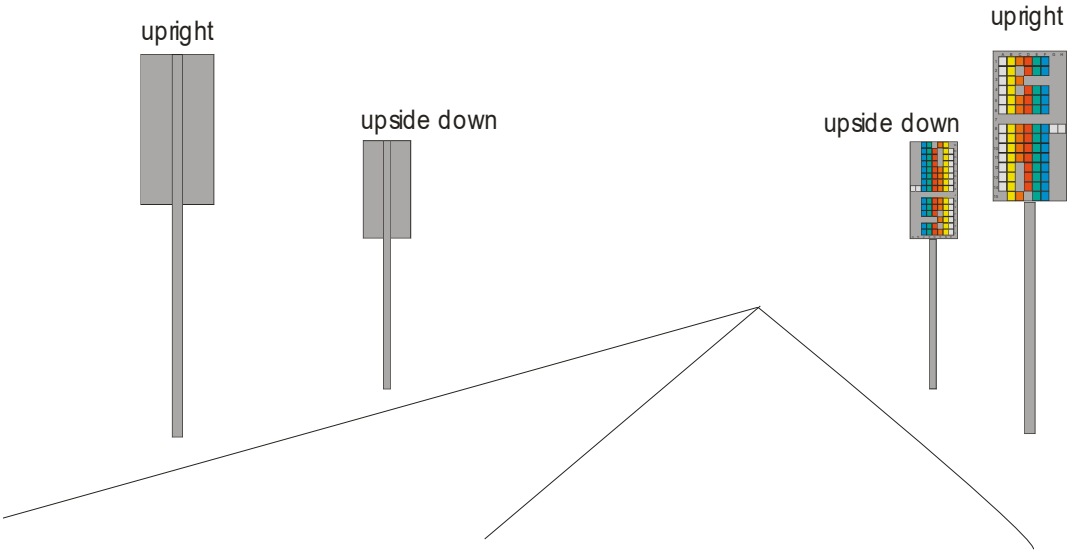


Figure 4. Arrangement of a trial site (source: Durability test of retro-reflecting materials for road signs at Nordic test sites)

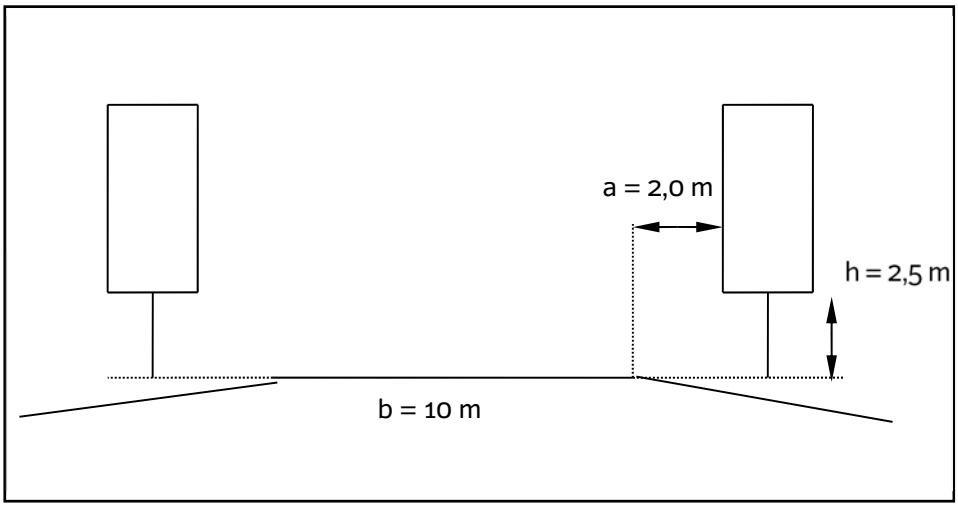


Figure 5. A cross-section of a trial site (source: Pohjoismainen liikennemerkki-kalvojen paluuheijastavuustutkimus; Väliraportti I (1997–1999) Suomi)

3.3 The layout of the trial signs

Each trial sign had 15 different types of reflective material in 7 different colors. Each material was attached to a tile made of steel, 10 x 10 cm in size (figures 6 and 12), screwed in the sign.

	Valmistaja ja kalvotyyppi	kalvo-luokka	A Val	B Kel	C Oran	D Pun	E Vih	F Sin	G Corlite 10 v	H Corlite 10 v	lkm
1	Stimsonite 6200 (HPG)	E							1G/ val	1H/ kel	8
2	Stimsonite 4500 (met.)	E							2G/pu	2H/ vih	7
3	Fasson 1500 (EG)	2									3
4	Fasson 2500 (SEG)	2+									5
5	3M 2200/3200 (EG)	2									6
6	3M 2800/3800 (HI)	1									6
7	Corlite 7 v	2	7A	7B	7C	7D	7E	7F			6
8	3M 3990 (DG/MP)	E							8G	8H	8
9	Seilbulite 7000/ 8000 (EG)	2									6
10	Seilbulite 17000/ 18000 (SEG)	2+									6
11	Seilbulite 700/ 800 (ULG)	1									6
12	Kiwalite 2000 (EG)	2									5
13	Kiwalite 12000 (SEG)	2+									5
14	Kiwalite 2200 (HI)	1									5
15	Reflexite	E									4
											86

Huom.

ei testikalvoa

vain Suomessa testattavat kalvot

8G ja 8H — 8G valk. antidugg ja 8H valk. Vandal sikker, valmistaja 3M ja kalvoluokka E

oik. yläänurkka — Corlite 10 v, kalvoluokka 1

Figure 6. Trial material layout in the trial sign (source: Pohjoismainen liikennemerkkikalvojen paluuheijastavuustutkimus; Väliraportti I (1997–1999) Suomi)

Some of the materials, which were only used in Finland (Corlite), were added to the Finnish trial signs, increasing the total amount of different materials in one trial sign to 86.

Each tile was identified in the vertical direction by numbers 1–15 and in the horizontal direction by letters A-H. E.g. 8G was specially designed for foggy conditions and 8H to be durable against graffiti.

3.4 The trial materials

Different reflective materials are presented in the following table (2) by category.

Table 2. *The classes of retro-reflective materials in Finland (source: Pohjoismainen liikennemerkkikalvojen paluuheijastavuustutkimus; Väliraportti I (1997–1999) Suomi)*

The classes of retro-reflective materials	Row	
Class E	**HPG- & DG- and other new materials**	
- new class, no official class ID yet	1	Stimsonite 6200 HPG
	2	Stimsonite 4500 met.
new level of reflectivity	8	3M 3990 DG
	15	Reflexite
	17	3M antidugg
	18	3M vandalsikker
Class 1	**HI- & ULG- materials**	
- currently used materials	6	3M 2800/3800
	11	Seibulite 700/ 800 ULG
	14	Kiwalite 22000
	16	Corlite 10 v.
Class 2+	**Super EG i.e. SEG materials**	
- improved level of reflectivity	4	Fasson 2500
	10	Seibulite 17000
	13	Kiwalite 12000
Class 2	**EG materials**	
- currently used materials	3	Fasson 1500
	5	3M 2200/ 3200
	9	Seibulite 7000/ 8000
	12	Kiwalite 2000
	7	Corlite 7 v.

The structure of the different types of retro-reflecting materials is shown in Figure 7 (in Finnish).

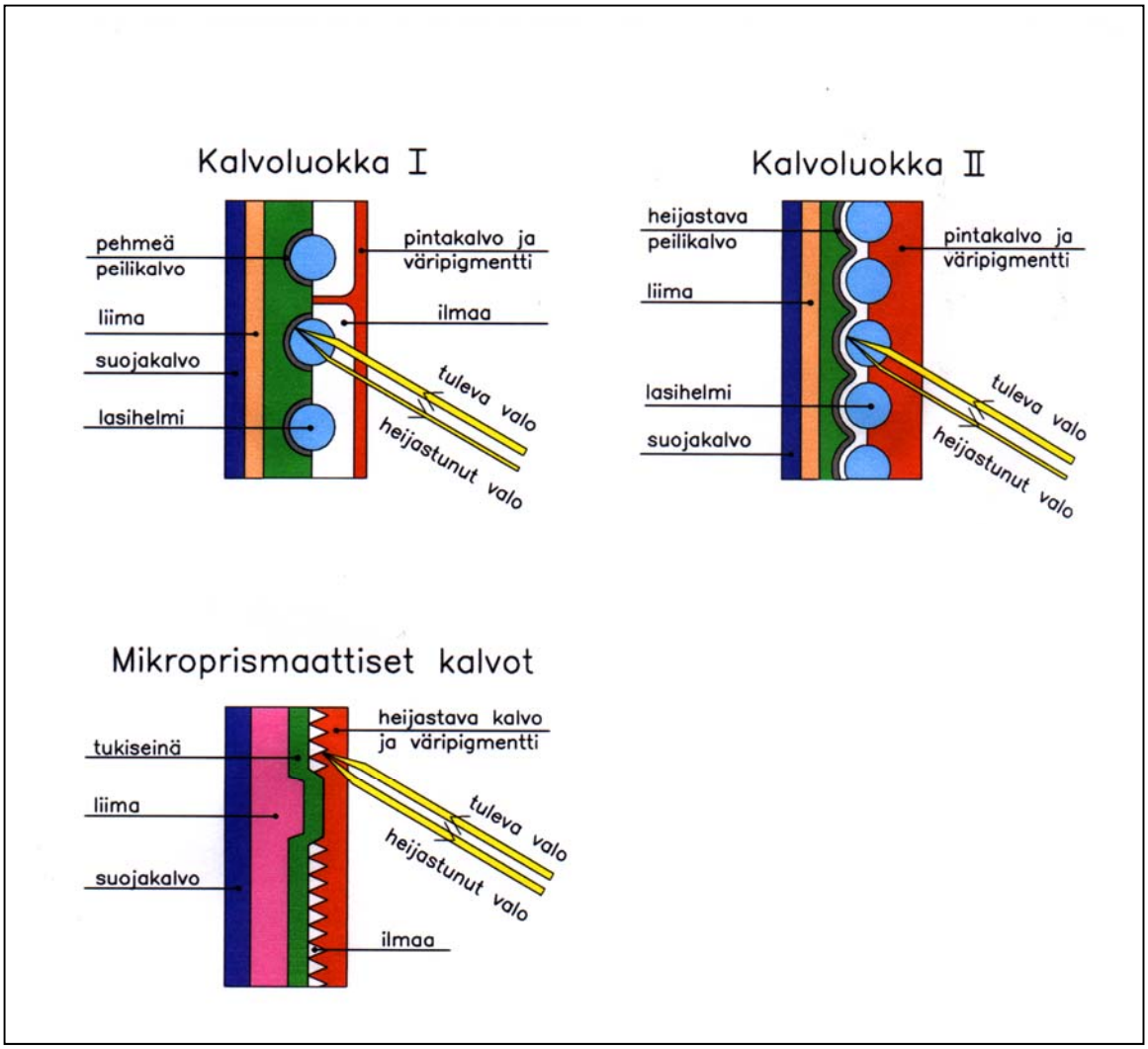


Figure 7. *The structures of class I, II and microprismatic retro-reflecting materials (source: Pohjoismainen liikennemerkkikalvojen paluuheijastavuus-tutkimus; Väliraportti I (1997–1999) Suomi)*

3.5 ID coding of trial materials and measurements

Each trial material and each of its measurement values were coded according to the coordinates of one sign [n, (A) to (H), see Figure 6] and, in addition, according to the orientation (south / north), posture (right side up, upside-down), country, site, color, surface type, time of measurement and some special characteristics. All these were coded in such a way that each measurement value became clearly defined (see annexes 2 and 3). This also made various types of analyses a lot easier.

3.6 Measurement program

The retro-reflectivity was initially measured every year from the signs standing on the site, either using an extension arm, a ladder or a crane. Later, as a practice, the sings were taken down for the measurement. Each procedure has its own pros and cons. Taking down and transporting the signs to the depot for measurement includes a risk of damage to the materials, while measuring on the site (figure 8) means additional risk of false measurements.

Figure 8. In-site measurements in Hakkila (September 2001, Timo Unhola)

In accordance with the program the signs were measured for retro-reflectivity in the summer, at the beginning of the trial each year, later less frequently, in years: 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2010, 2012, 2013 and 2016. Respectively this means that the signs were aged as following: 0, 1, 2, 3, 4, 5, 6, 7, 8, 13, 15, 16 and 19 years. The color coordinates were measured in years 2001, 2002, 2003, 2004, 2005 and 2016.

4 Measurements and methods

For the first few years only retro-reflectivity was measured but since 2001 also the color coordinates were measured.

The surfaces to be measured were wiped with a damp cloth approx. an hour before the measurement.

4.1 Retro-reflectivity

The retro-reflectivity of a traffic sign is measured near the surface by using a device that is especially designed for it. All measurements in Finland were made by means of a device called the RetroSign, which is developed by Danish Delta Light & Optics (a battery-operated device, Figure 9). To eliminate stray light a round shade around the front lens of the head was used. The value of retro-reflectivity of each measurement is stored by the device in unit cd / lx / m2.

4.1.1 Instrument

The instrument allows the surface to be measured for coefficient of retro-reflection RA in different angles of lighting and observation. In this trial a common European geometry (0,33° observation ja 5° entrance) was used. The specification details are presented in Annex 1.

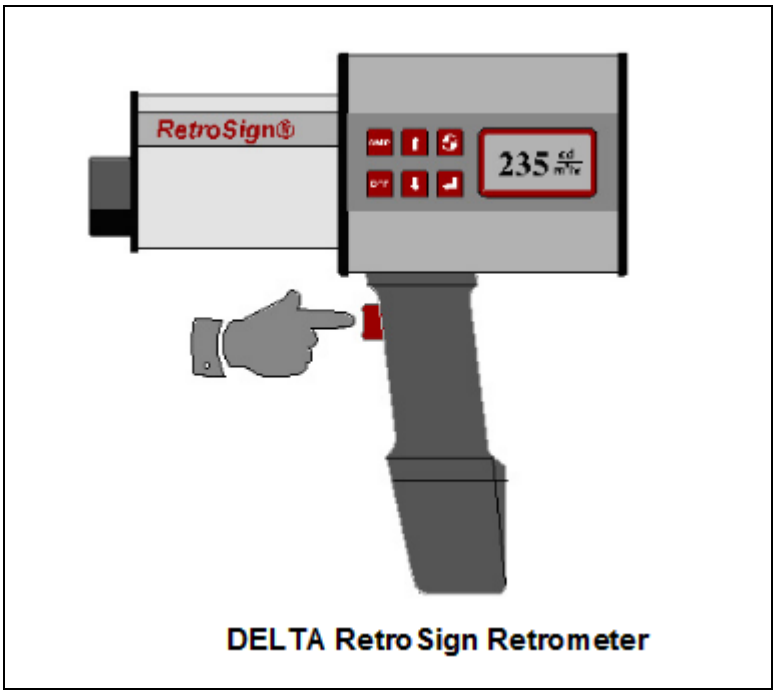


Figure 9. RetroSign-instrument

4.2 Luminance factor and color coordinates

Measurement of the color from the materials are to be measured in contact with the surface using a device, which measures the average of three measurements of the surface luminance and color coordinates (CIE), which is stored in the memory.

4.2.1 Instruments

In Finland the color measurements were made using Minolta color meters, type CR-331C (Figure 10) and in the last measurement, a similar device CM-2500c (Figure 11), both of which use the same geometry: 45° lighting angle and 0° measurement (observation) angle. Each instrument has a flash light according to the D65, but the measuring range of the CR-331C differs in diameter (25 mm), from that of the CM-2500c, which has Ø 7/11 mm.

Since in both instruments each measurement is the average of three measurements, the device CM-2500c has been relocated about 2 cm between each of the measurements, in order to obtain a representative average from each material.

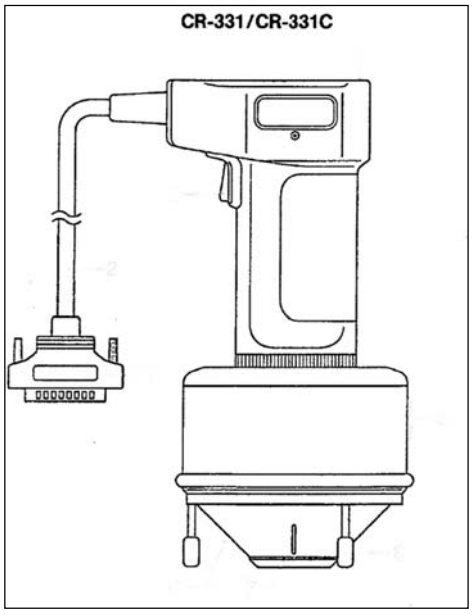


Figure 10. Older of MINOLTA meters, CR-331C (45/0, D65, Ø 25 mm)

Figure 11. KONICA MINOLTA CM-2500c (45/0, D65, Ø 7/11 mm)

5 Results

Since the test results values from Finland reached 10 signs x 86 material tiles = 860 values in both methods and in color measurement it is included both luminance and x and y coordinates, was the total count of the values every year, therefore, 4 x 860 = 3440.

In addition, the retro-reflectivity was confirmed by the last measurement occasions by sequential measurement by two different persons, values of which were averaged. The data was therefore in abundance (see. Annex 2 and 3).

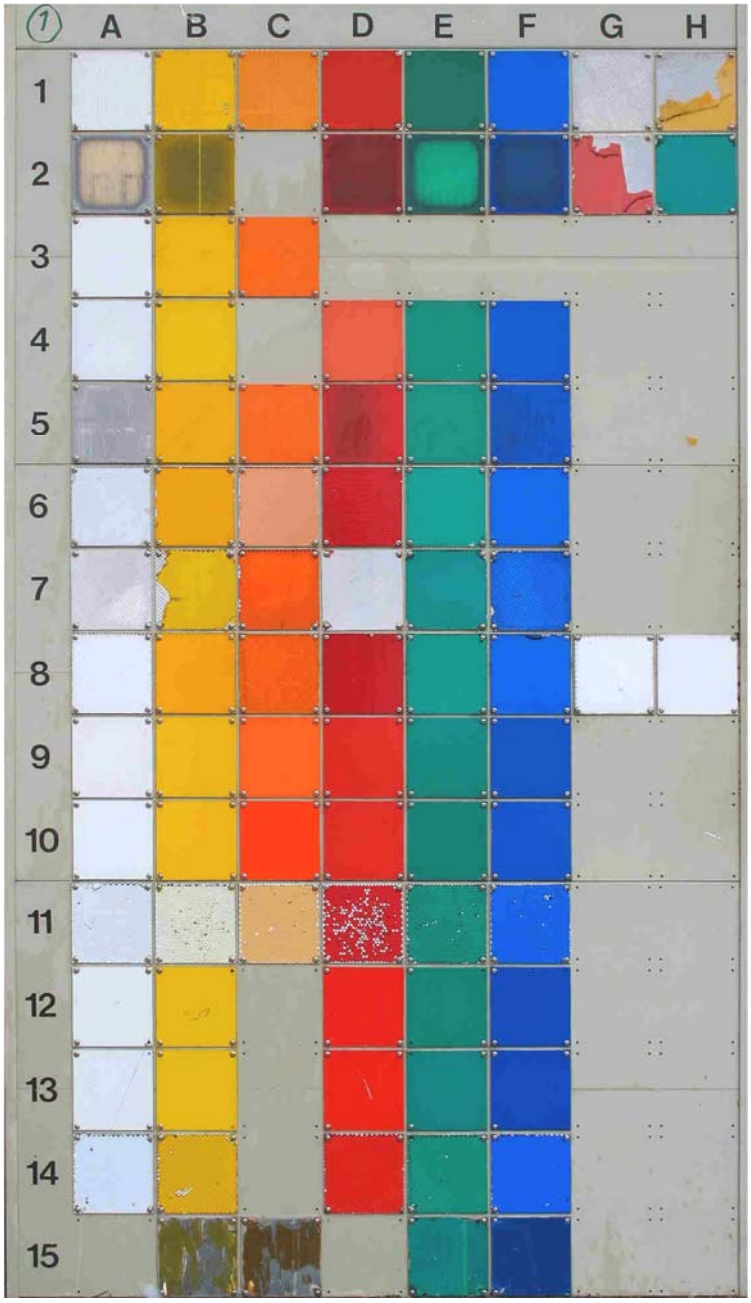


Figure 12. An example of a picture of the trial sign #1, along road #79, aged 19 years (picture June 2016, Timo Unhola).

5.1 Retro-reflectivity

The retro-reflectivity (R_A) is a physical quantity, expressed as $cd \cdot m^{-2} \cdot lx^{-1}$. It has been developed to express the visibility of objects (such as traffic signs) in vehicle lights at night.

Traffic sign performance requirements are set to retro-reflectivity, measured in accordance with a specific geometry. Different grades of materials and colors have their own requirements (Table 3).

In addition, the materials should keep their retro-reflectivity so that different parts of the material in class 1 has to retain its retro-reflectivity for at least 50% of the minimum value for 10 years and, correspondingly, the different parts of the material in class 2 for seven years.

The retro-reflectivity of any part of material made by silk-screen printing shall not exceed 30% lower of the minimum values of the table in both classes.

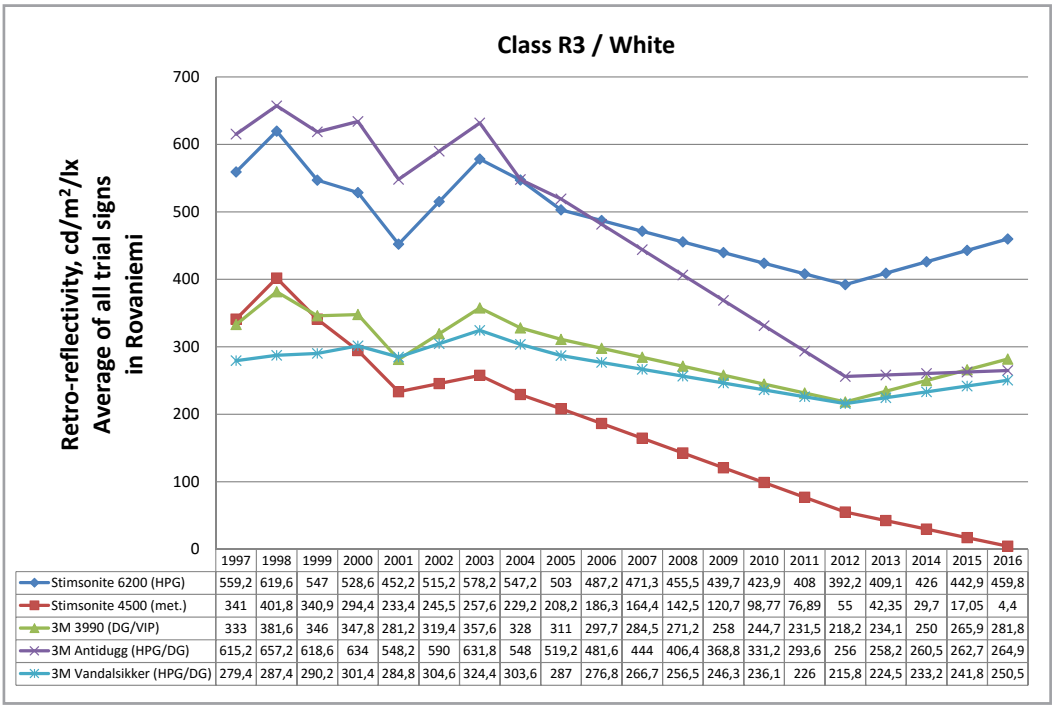
Table 3. Performance classes of retroreflective materials (source: Pohjoismainen liikennemerkkikalvojen paluuheijastavuustutkimus; Väliraportti I (1997–1999) Suomi

Performance classes of retroreflective sheetings (cd · lx-1 · m-2)					
	Condition class				
Class 1	5	4	3	2	1
White	180	144	108	72	< 72
Yellow	122	98	73	49	< 49
Orange	65	52	39	26	< 26
Red	25	20	15	10	< 10
Green	21	17	13	8	< 8
Blue	14	11	8	6	< 6
Class 2					
White	50	40	30	20	< 20
Yellow	35	28	21	14	< 14
Orange	20	16	12	8	< 8
Red	10	8	6	4	< 4
Green	7	6	4	3	< 3
Blue	2	2	1	1	< 1

The retro-reflectivity degrades over time. There are certainly many reasons for this, at least the outer surface contamination and scratching do lower reflectivity. Trial materials were wiped every time before the measurement, so that there was no dirt on the outer surface of the materials to undermine the results in this case.

The following figure (Figure 13) is an example of the change in the retro-reflectivity average of all the signs in Rovaniemi regarding some white materials. It should be noted that there is apparently a systematic error in the values from year 2012, which lowers the value of apparently 10 to 20%. The reason is unknown. The curve variations from the early years may also include similar errors, or else there has been a difference in cleaning technology.

The lowest curve represents the development of a completely damaged material towards result in year 2016 which seems to have not attributed to any external reason, but has been systematic and continuous.



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Stimsonite 6200 (HPG)	559,2	619,6	547	528,6	452,2	515,2	578,2	547,2	503	487,2	471,3	455,5	439,7	423,9	408	392,2	409,1	426	442,9	459,8
Stimsonite 4500 (met.)	341	401,8	340,9	294,4	233,4	245,5	257,6	229,2	208,2	186,3	164,4	142,5	120,7	98,77	76,89	55	42,35	29,7	17,05	4,4
3M 3990 (DG/VIP)	333	381,6	346	347,8	281,2	319,4	357,6	328	311	297,7	284,5	271,2	258	244,7	231,5	218,2	234,1	250	265,9	281,8
3M Antidugg (HPG/DG)	615,2	657,2	618,6	634	548,2	590	631,8	548	519,2	481,6	444	406,4	368,8	331,2	293,6	256	258,2	260,5	262,7	264,9
3M Vandalsikker (HPG/DG)	279,4	287,4	290,2	301,4	284,8	304,6	324,4	303,6	287	276,8	266,7	256,5	246,3	236,1	226	215,8	224,5	233,2	241,8	250,5

Figure 13. An example of the change in the average of retro-reflectivity from all the trial signs in Rovaniemi regarding some white materials after 19 years of aging.

5.1.1 Repeatability

On several occasions in repeatability of retro-reflectivity measurement a problem was found.

When two people measured the same materials ostensibly in the same manner, it was obtained, in the worst case, up to 170 cd / lx / m2 difference (99 vs. 269). There were several other smaller but significant differences in the measurement (fig. 14). On closer inspection, it turned out that all the measurements with major differences were from so-called micro-prismatic materials. Apparently, the light reflected from these materials varied considerably in a small area or between different position angles of the meter handle. Since it was not a well-known phenomenon, in spite of the differences between the measurements the value was taken as the average of these two measurements.

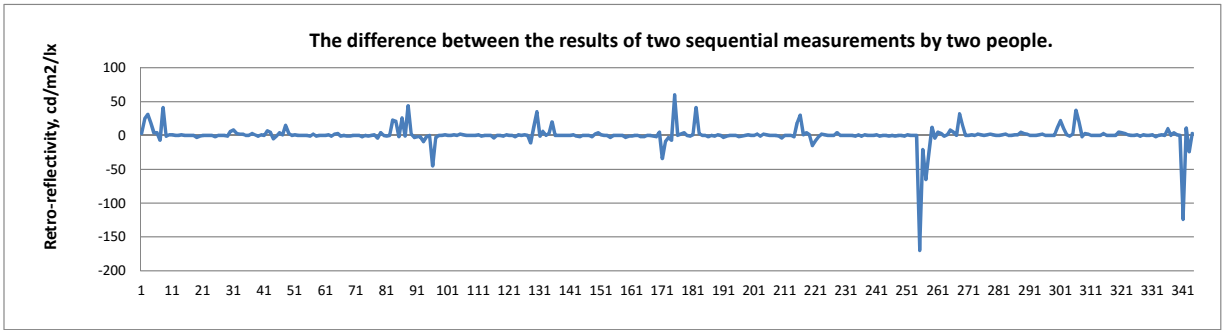


Figure 14. The difference between the results of two measurements of different people.

5.1.2 The effect of the cardinal direction or location of the signs to retro-reflectivity

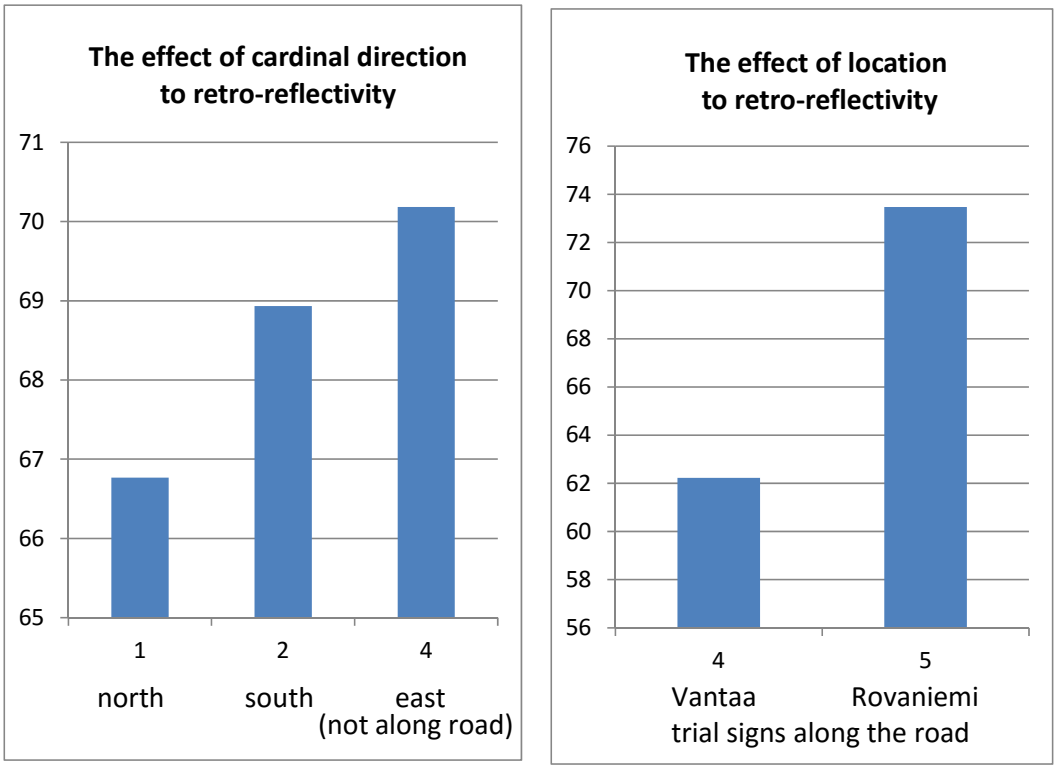


Figure 15. Effect of the cardinal direction or location of the signs to retro-reflectivity

It can be concluded that the loss in retro-reflectivity of the materials is almost independent of direction. Averages between the different directions show only small differences as indicated in Figure 15. The analysis included all signs whether they were along the road or not.

The effect of trial site is somewhat more pronounced. In Vantaa, the average of retro-reflectivity of all the signs along the road is 11 cd / m2 / lx lower than in Rovaniemi.

5.2 Color coordinates and luminance factor

5.2.1 Color coordinates

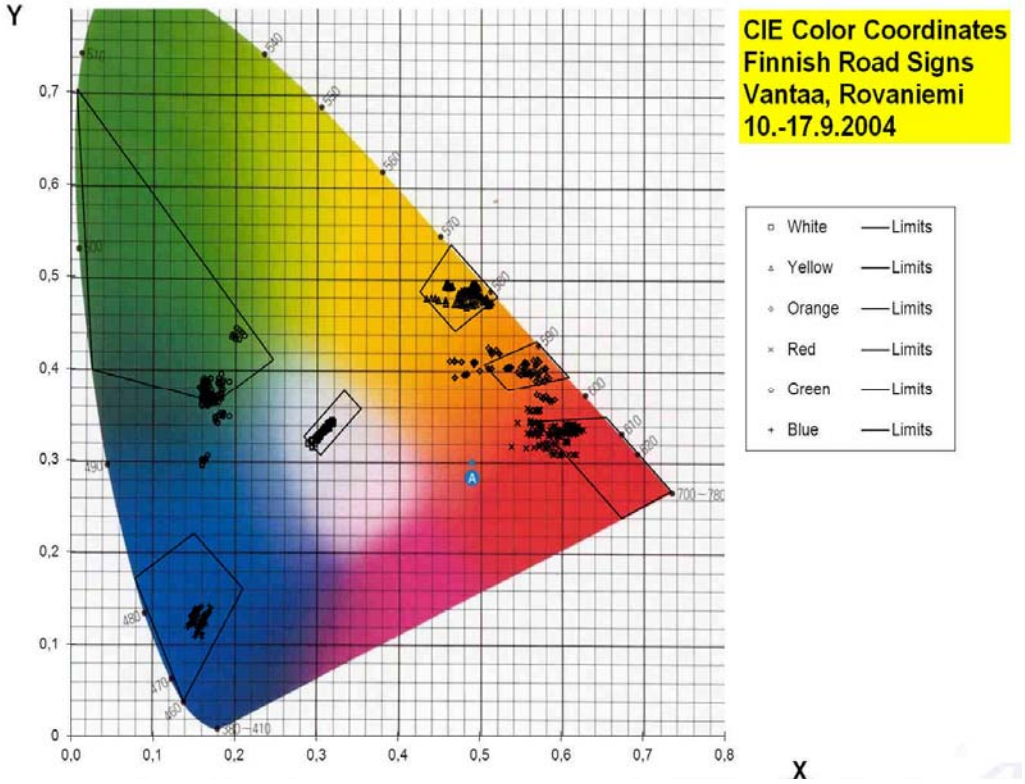


Figure 16. Trial material colors in CIE-coordinates in 2004. Requirement areas are presented as quadrilaterals.

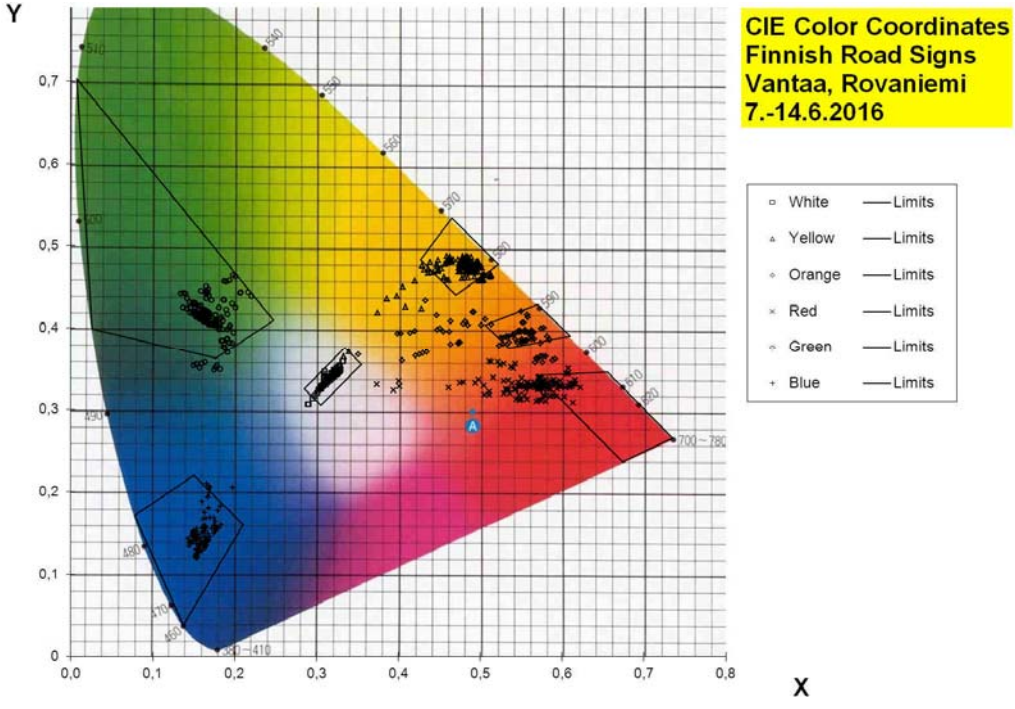


Figure 17. Trial material colors in CIE-coordinates in 2016. Requirement areas are presented as quadrilaterals.

Material colors outside requirement areas in 2016 (figure 17):

Vantaa (4):
White (1) 0/ 68 (north (2) 0/34, south (1) 0/34)
Yellow (2) 6/64 (north (2) 5/32, south (1) 1/32) outside rows 11, 15
Orange (3) 16/40 (north (2) 8/20, south (1) 8/20) outside rows 6, 11 ja 15, row 10 too red
Red (4) 0/56 (north (2) 0/28, south (1) 0/28) outside rows 6, 11 ja 15
Green (5) 4/60 (north (2) 2/30, south (1) 2/30) outside row 15
Blue (6) 4/56 (north (2) 2/28, south (1) 2/28)

Rovaniemi (5):
White (1) 2/ 68 (north (2) 0/34, south (1) 2/34)
Yellow (2) 8/64 (north (2) 6/32, south (1) 2/32) outside rows 11, 15
Orange (3) 18/49 (north (2) 8/20, south (1) 6/20) outside rows 6, 11 ja 15 (a few in row 1)
Red (4) 32/56 (north (2) 20/28, south (1) 12/28) outside almost all rows, least in rows 1, 5, 12.
Green (5) 4/60 (north (2) 2/30, south (1) 2/30) outside row 15
Blue (6) 0/56 (north (2) 0/28, south (1) 0/28)

General comments:
White materials have remained in the requirement area, if the film is in place.
The yellow materials have faded or shifted towards white (about one tenth of them).
The orange materials have faded or shifted towards yellow or are already in the beginning of the trial (2004) too red (row 10).
The reds have faded (already in the beginning in the corner of the requirement area) or moved in the direction of orange but only in Rovaniemi. The reason for this single clear difference between the places of trial signs is not evident.
The green materials have moved towards blue (only a dozen or so), or are already in the beginning of the trial (2004) too blue.
The blues have faded (only a few).

The orange color is used only very little (transport of dangerous goods) in Finnish traffic signs, so their transitions is hardly a cause for concern. A strong fading, darkening or shifting in the direction of yellow of the red color can instead be a problem. However, this was not very apparent if not including the shedding of the color films, which of course lead to complete change of the color to meet the color of the layer underneath (often white).

In summary, about the colors it could be said that although the colors of a large part of the trial materials have moved quite beyond the strict requirement areas, it still does not, however, lead to a misinterpretation of the signs except in cases where the film is separated from the base and the color completely changed (often to white).

5.2.2 Luminance factor

The luminance factor describes the visibility of traffic signs (brightness) in the light of the day. It is expressed as a ratio between 0 and 1 (or 100), where 0 is completely black and 1 (or 100) is the brightest possible value. Since the luminance factor is measured in the same geometry as the colors (45/0), it can be said to correspond to the midday sun lit directly to the traffic sign.

Because the different colors absorb light in very different ways, there are major differences between the requirements for different colors. The minimum requirement for white is 0.35 and for blue 0.01, for example.

The luminance factor could be expected to change more in materials towards the sun than the ones facing north. This does not, however, appear on the averages (Figure 18): the materials along the road were just a little bit darker facing north than facing south. Both of them had faded to some degree when they are validated against the reference sign materials.

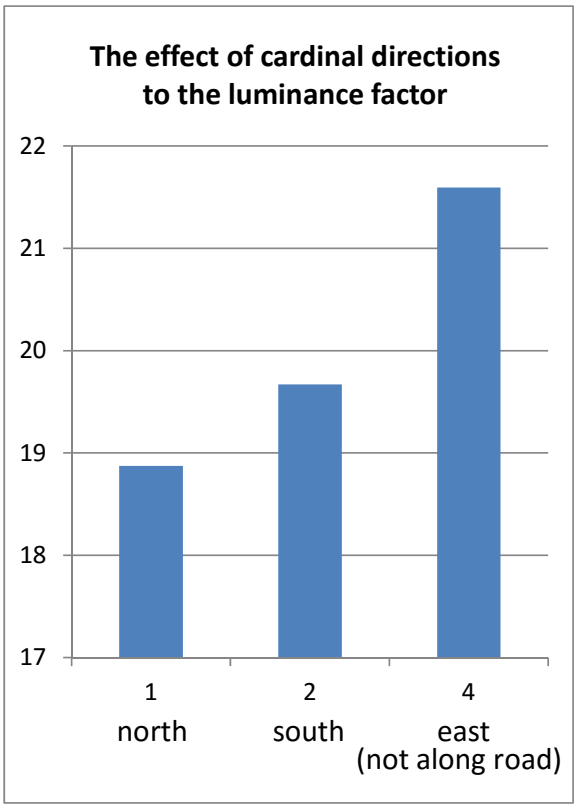


Figure 18. The effect of cardinal directions to the luminance factor

Especially white materials in rows 2, 5, 11 and 14 did not meet the requirement. They were in all trial signs after 19 years below the minimum requirement limit of 0.35. Nevertheless, it's worth mentioning that materials in rows 11 and 14 still did retro-reflect very well.

In other words, the deterioration of the day visibility does not necessarily lead to the deterioration of the night visibility (see figure 19). The white materials in row 7 were especially bright when measured in this geometry, even if they are far from the whitest in diffuse light as can be seen from the pictures (Figure 12). This may be an indication of the lack of the ability of the measurement methods used for this purpose to simulate all possible lighting conditions.

5.3 A summary of all the results

The dependence of day visibility on night visibility is not very clear (see. Figure 19). This is particularly striking regarding materials in row 1, which reflect well (see. Cover art), but do not during the day seem especially white (see. Figure 12).

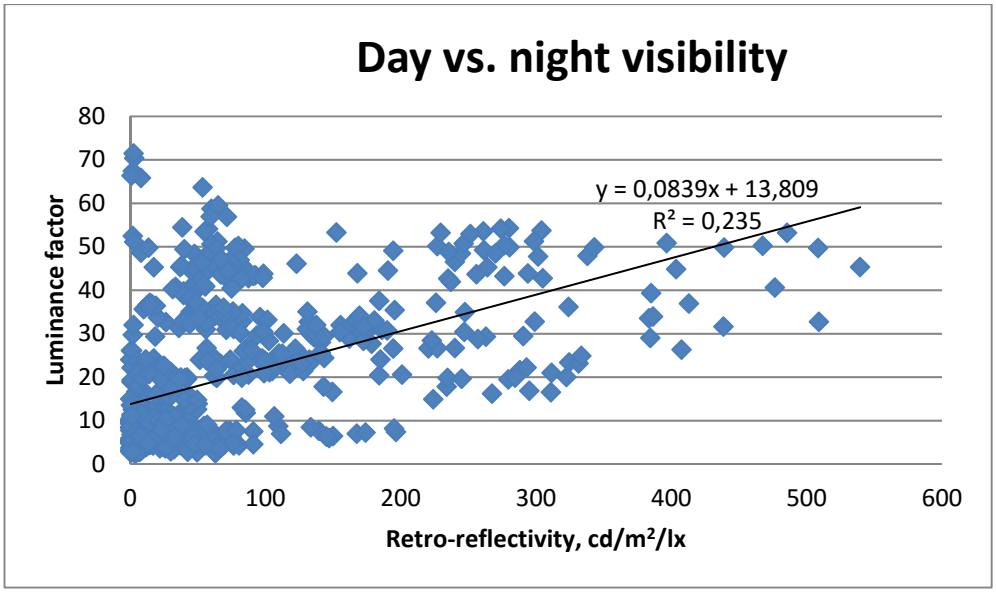


Figure 19. The dependence of day visibility on night visibility (all materials after 19 years).

5.3.1 Compliance with the requirements

When comparing the compliance with the requirements of the materials in different locations (Table 4), it is evident that the impact of traffic on the south has not affected the performance of the materials as much as the default, in fact, on the contrary. Fewer of the south-facing materials didn't meet the requirements than the north-facing ones in the trial signs in Vantaa. This is contrary to the expected results since the south-facing boards receive the most sunlight. The worst situation was found completely outside of the influence of the traffic, observing the trial sign in the courtyard of the depot in Rovaniemi (see table 4, table 5). The red colors have been most affected. Because of these changes in red colors of this sign, only 4 materials of the 14 met the color requirement. Special for this sign was that it was the only one measured now, which was facing to the east.

Explanatory factors can only be speculated: could the dirt on the materials protect them from ultraviolet UV light?

The durability of the retro-reflective materials can be given of good overall rating: over 64% i.e. nearly two-thirds of all of the materials in this trial met the requirements of a new retro-reflective material yet after exposure of 19 years (table 4). The most of the non-compliances with the requirements was due to the color changes.

In general, the trial of the 20-year-old materials does not give much information about the performance of the further developed materials available today.

Table 4. The summary of compliance with the requirement of new materials at the age of 19 years

		Compliance with the requirement	
Vantaa	Sign 1	22/86	
	Sign 2	20/86	
	Sign 3	33/86	
	Sign 4	35/86	
Rovaniemi	Sign 1	34/86	
	Sign 2	34/86	
	Sign 3	36/86	
	Sign 4	28/86	
	Sign 5	37/84	
Total		279/772	
Not fulfilling			36 %
Fulfilling			64 %

5.4 Other comments

A part of the screws that were used to attach the tiles supporting the trial materials was of quite rusting quality. Especially in Vantaa signs, obvious trails of brown dissolved rust can be seen running down from some of the screws (see. Annex 2). This was presumably because of the not suitable tile screws installed just in Finland later on.

As it is, the Vantaa signs did build up dirt much more than in Rovaniemi, as expected. It didn't, however, apparently cause deterioration of the results from the materials that were wiped before measurement.

The attachment with screws of the small steel tiles, sized 10 x 10 cm, supporting the materials, could contribute in some cases, to the detachment of the color film, as the film detachment seemed to begin with cleaving from beneath the corner screws.

Sources

Pohjoismainen liikennemerkkikalvojen paluuheijastuvuustutkimus; Väliraportti I (1997–1999) Suomi (Havu, Linsén, v. 2000)

Durability test of retro-reflecting materials for road signs at Nordic test sites – Ageing model for the retro-reflectivity after further exposure. Kai Sørensen, April 2011

Retro Sign - technical specifications

Optical specifications Type 4000

Geometry: DIN 67520 5° / 0.33°

Entrance angle:	+5°
Observation angle:	0.33°
Light source angular aperture:	0.16°
Receiver angular aperture:	0.16°
Field of measurement, Ø:	30 mm / 1.2 inch
Spectral responsivity:	Illuminant A and V(λ) efficiency according to ASTM E1709 para, 6.4.2. for selected filters.
Range ($cd \cdot lx^{-1} \cdot m^{-2}$):	0 – 2000

Electrical characteristics

EMC:	EN50081-1/EN50082-1
Power supply:	replaceable NiCd battery 9.6 V, 1.2 Ah (Bosch part no. 2 607 335 012)
External charger:	mains 230 V AC / 50 Hz optional 110 V / 60 Hz charge time approx. 15 minutes
Data memory:	~ 1000 measurements
Data retention:	typ. 5 years
Interface:	RS232

Environmental specifications

Temperature:	operating	0°C to + 45°C (32°F to 113°F)
	storage	- 15°C to + 55°C (5°F to 131°F)
Humidity:		non condensing

Instrument dimensions

Length:	295 mm / 11.6 inch
Width:	83 mm / 3.3 inch
Height:	324 mm / 12.8 inch
Weight:	2.1 kg / 4.6 lbs
Gross weight, approx.:	6.0 kg / 13.2 lbs

An example of a data table, Vantaa, sign 1 (red = non compliant)

Road Sign Sheetings Durability Nordic

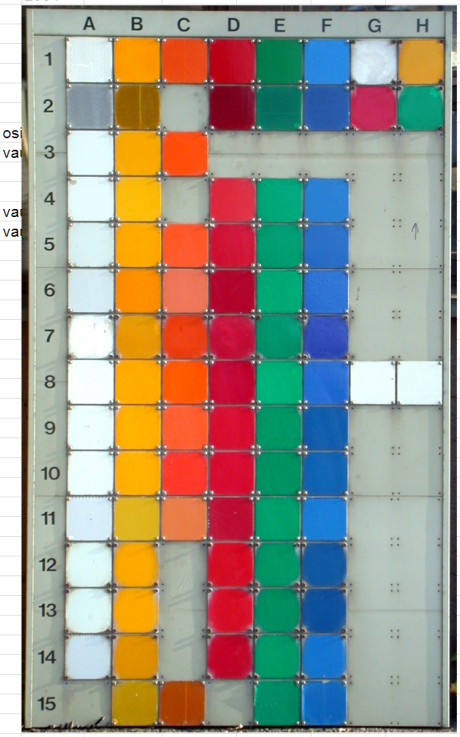
Vantaa 7.6.2016 punainen = ei täytä vaatimusta

R	Y	x	y	plats	tavla	folie	färg	typ	tid	riktning	sprayad	läge	
404	44,87	0,3125	0,3322	4	1	1	1	4	20	2	0	1A	
384	33,57	0,477	0,4754	4	1	1	2	4	20	2	0	1B	
312	21,01	0,5012	0,4029	4	1	1	3	4	20	2	0	1C	
168	7,04	0,5748	0,3382	4	1	1	4	4	20	2	0	1D	
74	7,61	0,2075	0,4423	4	1	1	5	4	20	2	0	1E	
42	6,23	0,1537	0,1441	4	1	1	6	4	20	2	0	1F	
48	39,46	0,3278	0,3448	4	1	1	1	3	20	2	0	1G	
106	22,96	0,4592	0,4588	4	1	1	2	3	20	2	0	1H	kalvo osi
1	26,14	0,3251	0,3494	4	1	2	1	4	20	2	0	2A	kalvo va
22	11,9	0,4395	0,468	4	1	2	2	4	20	2	0	2B	
3	4,2	0,5312	0,3247	4	1	2	4	4	20	2	0	2D	
0	10,23	0,1905	0,4216	4	1	2	5	4	20	2	0	2E	kalvo va
0	4,79	0,1696	0,207	4	1	2	6	4	20	2	0	2F	kalvo va
31	11,42	0,4759	0,3325	4	1	2	4	3	20	2	0	2G	
26	9,2	0,198	0,38	4	1	2	5	3	20	2	0	2H	
71	44,85	0,3054	0,3243	4	1	3	1	1	20	2	0	3A	
46	35,09	0,4734	0,4741	4	1	3	2	1	20	2	0	3B	
27	21,87	0,5485	0,3945	4	1	3	3	1	20	2	0	3C	
85	49,59	0,3095	0,3369	4	1	4	1	2	20	2	0	4A	
53	41,2	0,4613	0,48	4	1	4	2	2	20	2	0	4B	
50	13,93	0,5241	0,3534	4	1	4	4	2	20	2	0	4D	
11	10,3	0,1732	0,4332	4	1	4	5	2	20	2	0	4E	
4	5,23	0,1545	0,1544	4	1	4	6	2	20	2	0	4F	
5	22,6	0,324	0,3428	4	1	5	1	1	20	2	0	5A	
10	35,69	0,4923	0,4686	4	1	5	2	1	20	2	0	5B	
25	21,42	0,5284	0,3874	4	1	5	3	1	20	2	0	5C	
2	5,71	0,55	0,3281	4	1	5	4	1	20	2	0	5D	
6	7,2	0,1763	0,4041	4	1	5	5	1	20	2	0	5E	
1	3,4	0,1783	0,1548	4	1	5	6	1	20	2	0	5F	
132	32,77	0,3075	0,3273	4	1	6	1	3	20	2	0	6A	
108	23,58	0,4989	0,4578	4	1	6	2	3	20	2	0	6B	
52	24,01	0,4305	0,3679	4	1	6	3	3	20	2	0	6C	
21	5,55	0,5297	0,3183	4	1	6	4	3	20	2	0	6D	
22	8,44	0,1715	0,4152	4	1	6	5	3	20	2	0	6E	
13	4,88	0,1625	0,1576	4	1	6	6	3	20	2	0	6F	
2	52,51	0,3302	0,3472	4	1	7	1	1	20	2	0	7A	
64	24,05	0,4741	0,4685	4	1	7	2	1	20	2	0	7B	
10	21,19	0,5352	0,3828	4	1	7	3	1	20	2	0	7C	
4	15,93	0,499	0,3358	4	1	7	4	1	20	2	0	7D	
15	10,65	0,194	0,3818	4	1	7	5	1	20	2	0	7E	
1	6,8	0,1744	0,1579	4	1	7	6	1	20	2	0	7F	
262	49,25	0,3131	0,3331	4	1	8	1	4	20	2	0	8A	
221	26,67	0,5032	0,4593	4	1	8	2	4	20	2	0	8B	
280	19,52	0,552	0,4058	4	1	8	3	4	20	2	0	8C	
69	4,52	0,5452	0,3117	4	1	8	4	4	20	2	0	8D	
53	7,75	0,1653	0,4106	4	1	8	5	4	20	2	0	8E	
30	4,58	0,164	0,145	4	1	8	6	4	20	2	0	8F	
195	49,12	0,3134	0,335	4	1	8	1	4	20	2	0	8G	
191	44,54	0,3154	0,3373	4	1	8	1	4	20	2	0	8H	
64	46,24	0,3088	0,3287	4	1	9	1	1	20	2	0	9A	
50	34,47	0,4808	0,4776	4	1	9	2	1	20	2	0	9B	
42	19,97	0,5497	0,3824	4	1	9	3	1	20	2	0	9C	
13	7,72	0,5731	0,3289	4	1	9	4	1	20	2	0	9D	
10	6,43	0,165	0,4206	4	1	9	5	1	20	2	0	9E	
4	3,45	0,1663	0,1395	4	1	9	6	1	20	2	0	9F	
88	43,98	0,3091	0,3291	4	1	10	1	2	20	2	0	10A	
72	32,09	0,4824	0,4761	4	1	10	2	2	20	2	0	10B	
22	15,85	0,569	0,3616	4	1	10	3	2	20	2	0	10C	
24	8,32	0,5629	0,3285	4	1	10	4	2	20	2	0	10D	
13	5,28	0,1695	0,4031	4	1	10	5	2	20	2	0	10E	
6	3,49	0,1642	0,1402	4	1	10	6	2	20	2	0	10F	
156	31,98	0,3066	0,3254	4	1	11	1	3	20	2	0	11A	
103	28,37	0,3753	0,4187	4	1	11	2	3	20	2	0	11B	
92	25,54	0,4197	0,3955	4	1	11	3	3	20	2	0	11C	
31	7,72	0,5043	0,329	4	1	11	4	3	20	2	0	11D	
23	6,79	0,1793	0,4058	4	1	11	5	3	20	2	0	11E	
8	5,6	0,162	0,1575	4	1	11	6	3	20	2	0	11F	
53	43,51	0,315	0,3357	4	1	12	1	1	20	2	0	12A	
45	33,44	0,4852	0,4803	4	1	12	2	1	20	2	0	12B	
21	8,74	0,5878	0,3316	4	1	12	4	1	20	2	0	12D	
7	6,76	0,167	0,4065	4	1	12	5	1	20	2	0	12E	
4	3,22	0,1745	0,1486	4	1	12	6	1	20	2	0	12F	
77	43,72	0,3172	0,3374	4	1	13	1	2	20	2	0	13A	
50	33,75	0,4872	0,4802	4	1	13	2	2	20	2	0	13B	
22	8,93	0,5869	0,3337	4	1	13	4	2	20	2	0	13D	
14	6,17	0,1686	0,4116	4	1	13	5	2	20	2	0	13E	
5	3,22	0,1775	0,1524	4	1	13	6	2	20	2	0	13F	
141	28,04	0,3072	0,3257	4	1	14	1	3	20	2	0	14A	
103	21,18	0,4814	0,4746	4	1	14	2	3	20	2	0	14B	
39	7,4	0,5531	0,3288	4	1	14	4	3	20	2	0	14D	
19	7,76	0,1723	0,4031	4	1	14	5	3	20	2	0	14E	
9	5,11	0,164	0,1557	4	1	14	6	3	20	2	0	14F	
20	11,61	0,3206	0,3469	4	1	15	2	4	20	2	0	15B	kalvo vaurioitunut
21	11,77	0,3289	0,3437	4	1	15	3	4	20	2	0	15C	kalvo vaurioitunut
53	5,19	0,1829	0,3488	4	1	15	5	4	20	2	0	15E	kalvo osittain irti
22	3,68	0,1749	0,1683	4	1	15	6	4	20	2	0	15F	kalvo osittain irti

See comments and observations below (O43,473)

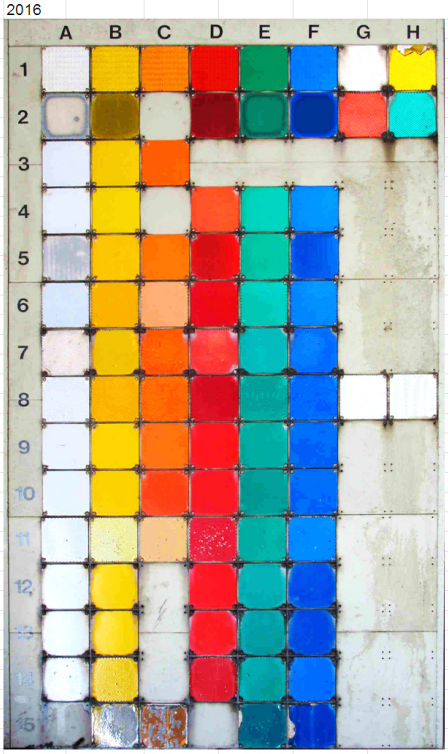
Pictures (comments)

2004



Comment

2016



An example of a data table, Rovaniemi, sign 5 (red = non compliant)

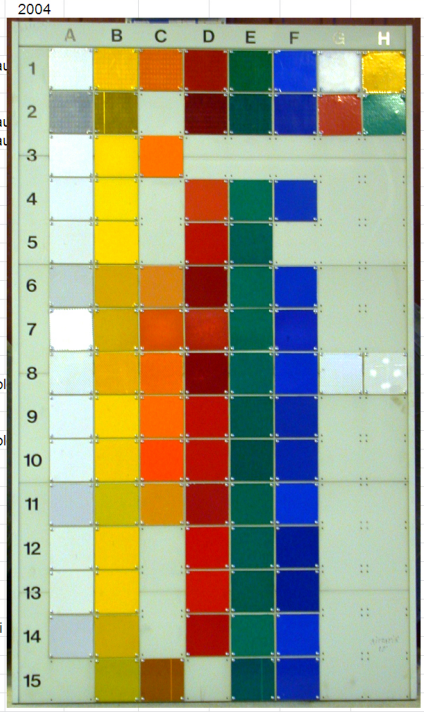
Road Sign Sheetings Durability Nordic
Rovaniemi 14.6.2016

punainen = ei täytä vaatimusta

See comments and observations below (O43,473)
Pictures (comments)

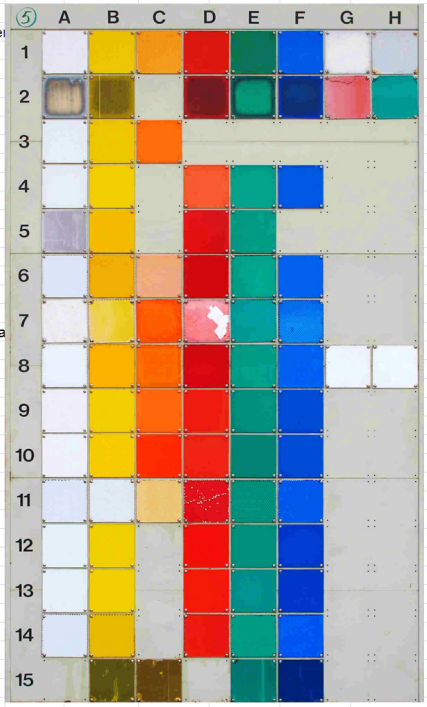
R	Y	x	y	plats	tavla	folie	färg	typ	tid	riktning	sprayad	läge	
486	53,24	0,3089	0,3284	5	5	1	1	4	20	4	0	1A	
477	40,63	0,4673	0,4826	5	5	1	2	4	20	4	0	1B	
385	29,06	0,4643	0,4077	5	5	1	3	4	20	4	0	1C	
195	8,22	0,6074	0,3499	5	5	1	4	4	20	4	0	1D	
79	7,81	0,1887	0,4565	5	5	1	5	4	20	4	0	1E	
46	6,13	0,145	0,1384	5	5	1	6	4	20	4	0	1F	
8	65,87	0,3182	0,3356	5	5	1	1	3	20	4	0	1G	
184	37,6	0,3113	0,3296	5	5	1	2	3	20	4	0	1H	
0	15,03	0,3271	0,3513	5	5	2	1	4	20	4	0	2A	kalvo vau
22	10,45	0,43	0,4762	5	5	2	2	4	20	4	0	2B	
5	3,23	0,5326	0,3232	5	5	2	4	4	20	4	0	2D	
0	8,58	0,1877	0,4339	5	5	2	5	4	20	4	0	2E	kalvo vau
0	2,99	0,1695	0,1981	5	5	2	6	4	20	4	0	2F	kalvo vau
23	19,62	0,3944	0,3228	5	5	2	4	3	20	4	0	2G	
33	10,99	0,1923	0,3688	5	5	2	5	3	20	4	0	2H	
67	47,27	0,3012	0,3185	5	5	3	1	1	20	4	0	3A	
44	38,12	0,4759	0,4787	5	5	3	2	1	20	4	0	3B	
25	22,65	0,5491	0,3971	5	5	3	3	1	20	4	0	3C	
60	56,96	0,3111	0,3423	5	5	4	1	2	20	4	0	4A	
38	45,7	0,4616	0,4837	5	5	4	2	2	20	4	0	4B	
30	17,35	0,5113	0,3589	5	5	4	4	2	20	4	0	4D	
9	11,44	0,1669	0,4498	5	5	4	5	2	20	4	0	4E	
2	5,47	0,1486	0,1502	5	5	4	6	2	20	4	0	4F	
9	19,79	0,3239	0,3412	5	5	5	1	1	20	4	0	5A	
15	36,7	0,4946	0,4733	5	5	5	2	1	20	4	0	5B	
				5	5	5	3	1	20	4	0	5C	no sampl
4	7,25	0,6074	0,3275	5	5	5	4	1	20	4	0	5D	
7	6,88	0,1611	0,4149	5	5	5	5	1	20	4	0	5E	
				5	5	5	6	1	20	4	0	5F	no sampl
170	34,18	0,306	0,3259	5	5	6	1	3	20	4	0	6A	
144	24,43	0,5026	0,4639	5	5	6	2	3	20	4	0	6B	
90	26,25	0,4045	0,3596	5	5	6	3	3	20	4	0	6C	
48	4,63	0,5808	0,317	5	5	6	4	3	20	4	0	6D	
28	8,29	0,1573	0,4229	5	5	6	5	3	20	4	0	6E	
15	4,55	0,1526	0,1481	5	5	6	6	3	20	4	0	6F	
1	66,37	0,3178	0,3353	5	5	7	1	1	20	4	0	7A	
82	30,22	0,4091	0,4259	5	5	7	2	1	20	4	0	7B	
2	29,75	0,5238	0,378	5	5	7	3	1	20	4	0	7C	
3	32,05	0,4011	0,3336	5	5	7	4	1	20	4	0	7D	kalvo irti
18	10,59	0,1888	0,374	5	5	7	5	1	20	4	0	7E	
1	13,57	0,1974	0,2048	5	5	7	6	1	20	4	0	7F	
274	54,2	0,3083	0,328	5	5	8	1	4	20	4	0	8A	
247	30,45	0,5084	0,4636	5	5	8	2	4	20	4	0	8B	
334	24,92	0,5502	0,4208	5	5	8	3	4	20	4	0	8C	
76	4,88	0,5722	0,3108	5	5	8	4	4	20	4	0	8D	
57	7,86	0,151	0,4201	5	5	8	5	4	20	4	0	8E	
32	5,23	0,1572	0,1437	5	5	8	6	4	20	4	0	8F	
230	53,25	0,3121	0,3328	5	5	8	1	4	20	4	0	8G	
153	53,31	0,3108	0,3318	5	5	8	1	4	20	4	0	8H	omituine
57	48,11	0,3101	0,33	5	5	9	1	1	20	4	0	9A	
49	37,25	0,4729	0,4827	5	5	9	2	1	20	4	0	9B	
14	20,78	0,5462	0,3817	5	5	9	3	1	20	4	0	9C	
14	9,56	0,5514	0,3371	5	5	9	4	1	20	4	0	9D	
11	5,96	0,1431	0,4357	5	5	9	5	1	20	4	0	9E	
3	3,57	0,1593	0,1388	5	5	9	6	1	20	4	0	9F	
54	46,33	0,3097	0,3299	5	5	10	1	2	20	4	0	10A	
69	34,65	0,4786	0,4825	5	5	10	2	2	20	4	0	10B	
19	16,08	0,5738	0,3641	5	5	10	3	2	20	4	0	10C	
21	9,91	0,535	0,3356	5	5	10	4	2	20	4	0	10D	
13	4,74	0,1469	0,4178	5	5	10	5	2	20	4	0	10E	
5	3,5	0,1592	0,14	5	5	10	6	2	20	4	0	10F	
181	33,05	0,304	0,3231	5	5	11	1	3	20	4	0	11A	
131	35,07	0,3119	0,3343	5	5	11	2	3	20	4	0	11B	
114	30,11	0,3947	0,3907	5	5	11	3	3	20	4	0	11C	
38	8,94	0,5112	0,3222	5	5	11	4	3	20	4	0	11D	kalvossa
33	6,24	0,1599	0,4173	5	5	11	5	3	20	4	0	11E	
13	4,9	0,1524	0,1476	5	5	11	6	3	20	4	0	11F	
73	44,44	0,3131	0,333	5	5	12	1	1	20	4	0	12A	
51	33,76	0,4787	0,4872	5	5	12	2	1	20	4	0	12B	
24	9,18	0,5906	0,3354	5	5	12	4	1	20	4	0	12D	
8	6,38	0,1541	0,4137	5	5	12	5	1	20	4	0	12E	
4	3,13	0,1655	0,1405	5	5	12	6	1	20	4	0	12F	
83	42,74	0,3149	0,3345	5	5	13	1	2	20	4	0	13A	
69	36,02	0,4828	0,4877	5	5	13	2	2	20	4	0	13B	
27	10,18	0,5726	0,3387	5	5	13	4	2	20	4	0	13D	
19	6,56	0,1545	0,4129	5	5	13	5	2	20	4	0	13E	
5	2,84	0,1612	0,1343	5	5	13	6	2	20	4	0	13F	
173	31,58	0,3049	0,3238	5	5	14	1	3	20	4	0	14A	
127	23,03	0,4821	0,4855	5	5	14	2	3	20	4	0	14B	
57	9,04	0,5294	0,3338	5	5	14	4	3	20	4	0	14D	
23	7,81	0,1626	0,4077	5	5	14	5	3	20	4	0	14E	
13	4,82	0,1551	0,1461	5	5	14	6	3	20	4	0	14F	
1	11,41	0,4055	0,4507	5	5	15	2	4	20	4	0	15B	
1	11,07	0,4158	0,4353	5	5	15	3	4	20	4	0	15C	
56	4,37	0,1585	0,3496	5	5	15	5	4	20	4	0	15E	
2	2,83	0,1634	0,1798	5	5	15	6	4	20	4	0	15F	

2004



Very strange wear on Sign 5 sheet 8H (four worn patces very regularly spaced, not from measuring)

2016



ISSN-L 1798-6656
ISSN 1798-6664
ISBN 978-952-317-333-0
www.liikennevirasto.fi

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Finnish Transport Agency